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Dendrochaetidae, a new family of mites (Acari: Prostigmata), with descriptions of a new genus and species from South Africa

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A new family, Dendrochaetidae, and genus, *Dendrodus,* collected from soil samples from South Africa are diagnosed and described. An identification key separating the families of the superfamily Eupodoidea is presented. A new species, *Dendrodus acarus* is described and illustrated. The diagnostic morphological features are illustrated to be a combination of the type of setae of the idiosoma and appendages; palpal segmentation; the number and type of setae, rhagidial solenidia and erect solenidia of the palptarsus; presence and distribution of erect solenidia of leg segments; coxal chaetome; differences in the complement of cheliceral setae (cha and chb) and adoral setae (or$_1$ and or$_2$) and the number and distribution of dorsal idiosomal setae. The most essential diagnostic features of the new taxon are comparatively discussed for members of Penthaleidae and Pentapalpidae, selected species of Penthalodidae, Eupodidae and Rhagidiidae. Reference to similar features displayed by other prostigmatic mites (not representatives of Eupodoidea) is made.

Key words: *Dendrodus acarus,* Dendrochaetidae, Eupodoidea, South Africa.

INTRODUCTION

The original characterization of the superfamily Eupodoidea (Banks 1894) survived a number of changes concerning the familial and generic composition of the group. Vitzthum (1941), in an effort to consolidate previous taxonomic models, proposed that species belonging to the Eupodoidea be grouped into four families (Eupodidae Koch, Penthalodidae Thor, Penthaleidae Oudemans and Rhagidiidae Oudemans). This combination was, for almost four decades, unadventurously acknowledged by the acarological scientific community. Zacharda (1979) was the first to challenge the four-family model with the introduction of the fifth family, Strandtmanniidae. The most striking morphological features diagnosing Strandtmanniidae are the combination of five pairs of prodorsal setae and a neotrichous idiosomal chaetome. All other eupodoid species display only four pairs of prodorsal setae and, exceptionally and restricted to only a few species, more than the normal number (eight pairs) of idiosomal setae.

Since the inception of Strandtmanniidae, another two families were established, namely Eriorhynchidae (Qin & Halliday 1997) and Pentapalpidae (Olivier & Theron 1999).

This report deals with another proposed new family, collected in soil samples from South Africa, to be slotted into the definition of the Eupodoidea. The proposed new family is diagnosed and an identification key separating the families of the superfamily Eupodoidea is presented. A new genus and species are described and illustrated and the most important diagnostic features of the new taxon are compared with some congeners considered to be closely related. With this addition, 46 genera (19 representing monotypic genera) and more than 340 species are known worldwide (Qin 1996).

MATERIALS & METHODS

Material was collected using conventional soil sampling and extraction methods. Specimens were preserved in 70% ethanol, permanently mounted on glass microscope slides and studied with a high-resolution phase contrast microscope. Body length of specimens was measured from the posterior margin of the opisthosoma to the anterior extremity of the prodorsum. Body width was measured as the distance between the lateral extremities of the body on a line between the external humeral setae (**c**$_2$). Leg lengths represent the mid-line distance from the proximal margin of the

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trochanter to the distal margin of the tarsus. Setal lengths were recorded as the distance from the setal base to the tip of the seta. Curved setae were first drawn and then measured with a planimeter. All dimensions are mean values, given in micrometer (μm). Notations for setae and nomenclature follow that applied to eupodoids by Baker (1990) and as illustrated for eupodids and pentapalpids by Olivier & Theron (1997a,b, 1998, 1999). Abbreviations used are as follows: prodorsal setae – internal vertical (**iv**), external vertical (**ev**), trichobothria (**T**), scapular (**sc**); opisthosomal setae–internal humeral ($\mathbf{c}_1$), external humeral ($\mathbf{c}_2$), first dorsal ($\mathbf{d}_1$), second dorsal ($\mathbf{e}_1$), internal lumbar ($\mathbf{f}_1$), external lumbar ($\mathbf{f}_2$), internal sacral ($\mathbf{h}_1$), external sacral ($\mathbf{h}_2$); gnathosoma–external malae (**em**), internal malae (**im**); gnathosomal setae–basal subcapitular setae ($\mathbf{sbc}_1$), apical subcapitular setae ($\mathbf{sbc}_2$), adoral setae ($\mathbf{or}_1$ and $\mathbf{or}_2$), cheliceral setae (**cha** and **chb**); palpal setae–dorsals (**d**, $\mathbf{d}_1$ & $\mathbf{d}_2$), laterals (**l′** & **l″**), terminal prorals (**p′** & **p″**), ventral (**ba**); genital region–aggenital setae (**ag**), genital setae (**g**), eugenital setae (**eg**); anal region–pseudanal setae ($\mathbf{ps}_1$–$\mathbf{ps}_2$); podosomal region–coxal setae (**1a–1b**, **2a**, **3a–3b**, **4a–4b**); lyrifissures–**ia**, **im**, **ih**.

RESULTS

Diagnosis of Dendrochaetidae fam. n. (based on morphological features of females)

Soft-bodied, cuticle unsclerotized, with punctuated striae; dorsal opisthosoma with seven pairs of setae, lacking external lumbar seta ($\mathbf{f}_2$); sejugal furrow absent; prodorsum with prominently differentiated furrows (other than the sejugal); epirostrum absent; setae of idiosoma and appendages predominantly dendriform-spinose; coxal field II with one seta; with three pairs of ventral setae; genital shields with no more than six setae each, both aggenital – (**ag**) and genital setae (**g**) arranged in a single row; with two pairs of pseudanal setae ($\mathbf{ps}_1$–$\mathbf{ps}_2$); ectomalae situated on ventral surface (not the outer lateral margins) of subcapitular lateral lips; lateral lips lacking both adoral setae ($\mathbf{or}_1$ & $\mathbf{or}_2$); palp four-segmented; palptarsus with fewer than six setae; palptarsus with a rhagidial organ with one rhagidial solenidion; palptarsus with two terminal erect solenidia.

Etymology. Dendron (Gr) = tree, *chaeta* (Gr) = bristle or hair; refers to the type/shape of setae of the opisthosoma and appendages.

Key to families of Eupodoidea
(Mainly adapted from Qin & Halliday (1997), based on features of females)

1. Palp with five free segments (femur and genu not fused); adoral setae of unequal size, relatively large and easy to observe; coxal field II with two setae; trochanters I–IV with 0-1-2-1 setae; with two pairs of heteromorphic eugenital setae; genital shields each with four setae; apotele with unrayed empodium, claw-like, lacking lateral empodial claws
.... Pentapalpidae Olivier & Theron

— Palp with four free segments (with fused femurogenu); adoral setae mostly of equal size, sometimes small and difficult to observe; coxal field II with one or more than three setae; setal formula of trochanters I–IV other than 0-1-2-1; with more than two pairs of either hetero- or homomorhpic eugenital setae; genital shields each with more than four setae; apotele with rayed or ciliated pad-like empodium, supplemented with a pair of lateral empodial claws 2

2. Dorsal opisthosoma with more than eight pairs of setae; coxal fields II each with more than three setae; aggenital and genital setae irregularly arranged in three or more rows 3

— Dorsal opisthosoma with eight or fewer pairs of setae; coxal fields II each with one seta; aggenital and genital setae always arranged in fewer than three rows, sometimes with one genital seta situated more lateral than the rest, but more frequently arranged in single file 5

3. Prodorsum with five pairs of setae, including **T**; palptibia with one seta
.... Strandtmanniidae Zacharda

— Prodorsum with four pairs of setae, including **T**; palptibia with more than one seta.... 4

4. Palptibia with six or seven setae; gnathosomatic base (Qin & Halliday 1997) with 15–34 setae; naso-prodorsal process (Qin & Halliday 1997) present
.... Eriorhynchidae Qin & Halliday

— Palptibia with three setae; gnathosomatic base without setae; naso-prodorsal process absent..... Penthaleidae (in part) Oudemans

5. Integument prominently sclerotized; cuticle with polygonal or granular ornamentations; dorsal integument with distinct **V**- or **Y**-shaped furrow, or with parallel integu-

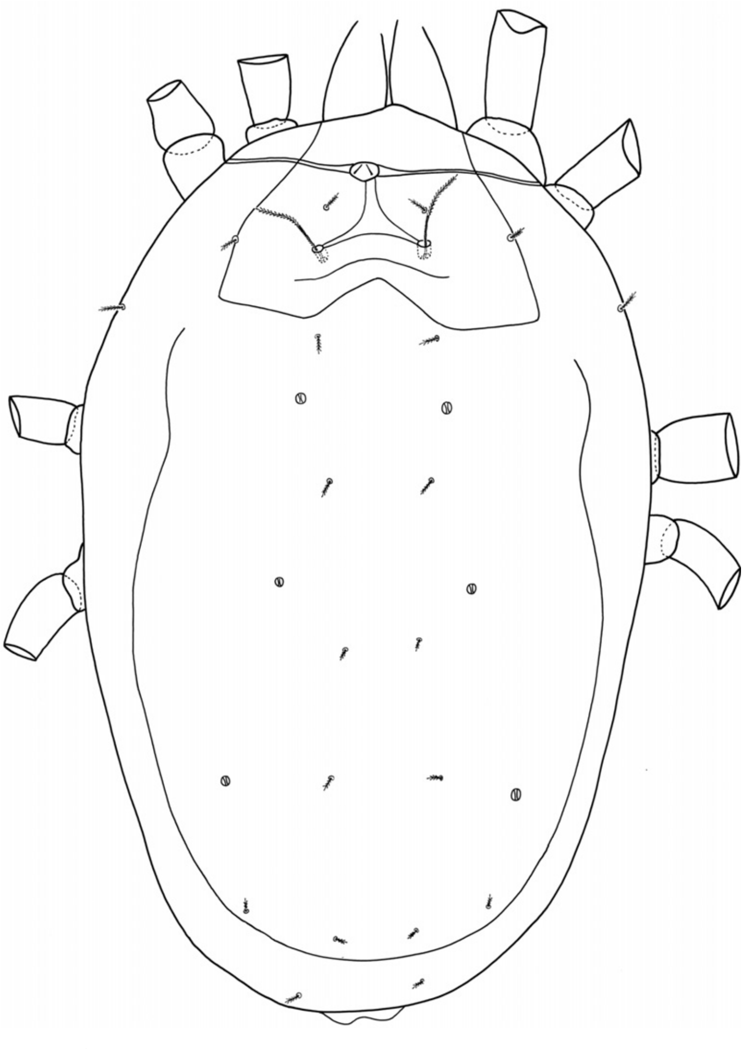

Fig. 1. *Dendrodus acarus* female, dorsal idiosoma.

mental furrows on opisthosomal shield; epirostrum present ..... Penthalodidae Thor

— Integument unsclerotized or only weakly sclerotized; cuticle not distinctly ornamented, sometimes punctuated; dorsal integument with or without furrows, but never **V**- or **Y**-shaped; epirostrum absent 6

6. Cheliceral shaft enlarged and swollen; cheliceral digits large, forming opposed cheliceral shears; palptibia with two or three setae; tarsi of legs with recumbent rhagidial solenidia only, never with erect solenidia .... Rhagidiidae Oudemans

— Cheliceral shaft not enlarged and swollen; cheliceral digits small; palptibia with three setae; tarsi of legs with recumbent rhagidial solenidia, with or without erect solenidia . . . 7

7. Sejugal furrow present; naso lobe-like, extending from prodorsum anteriorly; genital shields each with six setae; tarsi of legs without erect solenidia ..... Eupodidae Koch

— Sejugal furrow absent; prodorsum with or without additional (other than sejugal) furrows; tarsi of legs occasionally with erect solenidia 8

8. Prodorsum without additional (other than sejugal) integumental furrows; naso dome-like, defined immediately inside anterior margin of prodorsum; genital shields each with more than six setae; dorsal opisthosoma with more than seven pairs of setae; tarsi of legs of some species with erect

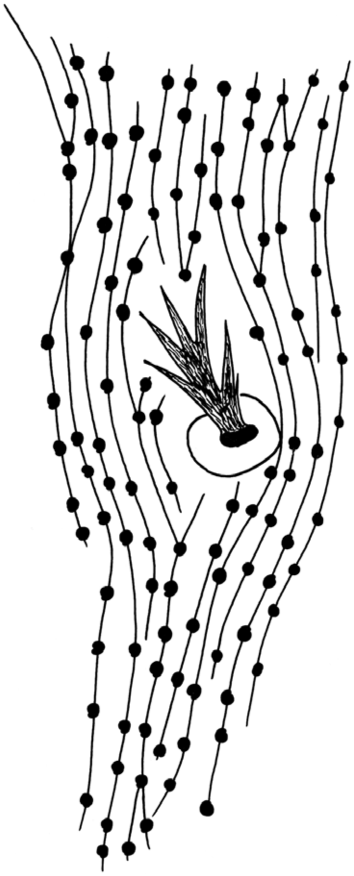

Fig. 2. *Dendrodus acarus* female, typical idiosomal seta.

solenidia . . Penthaleidae (in part) Oudemans
— Prodorsum with additional (other than sejugal) furrows; naso small, rounded, well separated from anterior prodorsal margin; genital shields each with six or fewer setae; dorsal opisthosoma with seven pairs of setae, lacking *f*$_2$; tarsi of legs always lacking erect solenidia . . . . . Dendrochaetidae fam. n.

Genus *Dendrodus* gen. n.

Type species: *Dendrodus acarus* gen. et sp. n.

Diagnosis. as per family designation and monotypy.

Dendrodus acarus sp. n., Figs 1–8

Female (Figs 1–8). *Size* (*n* = 7): body length 352 μm; body width 217 μm; leg I 173 μm; leg II 122 μm; leg III 134 μm; leg IV 150 μm; **iv** 10 μm; **ev** 14 μm; **T** 74 μm; **sc** 13 μm; **c**$_1$ 14 μm; **c**$_2$ 16 μm; **d**$_1$ 11 μm; **e**$_1$ 9 μm; **f**$_1$ 10 μm; **h**$_1$ 8 μm; **h**$_2$ 10 μm. *Body*: Idiosoma oval-shaped, longer than wide; dorsal opisthosomal integument with punctuated striae (Fig. 2); idiosomal setae (Fig. 2) all very small (except **T**, dendriform-spinose, except **iv** and **T** (Fig. 1).

Dorsal idiosoma. Prodorsum (Fig. 1) without a prominent prodorsal shield, but with sensory region, clearly demarcated, appearing slightly elevated from rest of prodorsal integument; naso very small, rounded, situated somewhat depressed and enfolded in a prominently differentiated transverse integumental furrow; a broad, inverted **Y**-shaped furrow is present from the base of the naso, posterolaterally to bases of **T**; **iv** small, filiform, simple, not associated with bothria, inserted on the mid-lateral margin of the naso; **T** filiform, very long compared to other prodorsal setae. Opisthosoma (Fig. 1) with fairly well-defined dorsal plate, delimited by integumental folds, appearing slightly elevated from rest of opisthosomal integument; opisthosomal chaetome hypotrichous with seven pairs of setae (**c**$_1$, **c**$_2$, **d**$_1$, **e**$_1$, **f**$_1$, **h**$_1$ and **h**$_2$), lacking seta **f**$_2$; all opisthosomal setae dendriform-spinose and relatively small, all situated on opisthosomal plate except **c**$_2$ which is present close to posterolateral margins of opisthosoma; lyrifissures present slightly lateral to opisthosomal setae, **ia** midway between **c**$_1$ and **d**$_1$, **im** midway between **d**$_1$ and **e**$_1$ and **ip** lateral to **f**$_1$; seta **ps**$_1$ visible in dorsal view.

Ventral idiosoma (Fig. 3). Coxae noticeably divided into two groups (I & II and III & IV); with three pairs of intercoxal ventral setae, one pair medially between coxae I, one pair medially and midway between coxae II and III and one pair medially between coxae IV (Fig. 3, see discussion); genital region with six pairs of **ag**-setae and six pairs of **g**-setae, both groups aligned; genital atrium with five pairs of homomorphic **eg**-setae; anal opening terminal, slit-like, flanked with two pairs of pseudanal setae (**ps**$_1$ situated dorsally on the pseudanal segment), in dorsal view the anal region appears like a posteriorly directed bi-lobed structure (Fig. 1); with one pair of lyrifissures (**ih**) present lateral to **ps**$_2$.

Gnathosoma. Subcapitular lateral lips terminally rounded; ectomalae (**em**) (Fig. 4) club-shaped, situated on the ventral surface of the lateral lips (not on the outer lateral margins of the lateral lips); entomalae (**im**) relatively large, lanceolate, terminally hooked; both **sbc**$_1$ and **sbc**$_2$ dendriform-spinose, of equal size; without either ***or***$_1$ or **or**$_2$; labrum rod-like, with a bubble-like inflated tip, not extending beyond apex of subcapitular lateral lips;

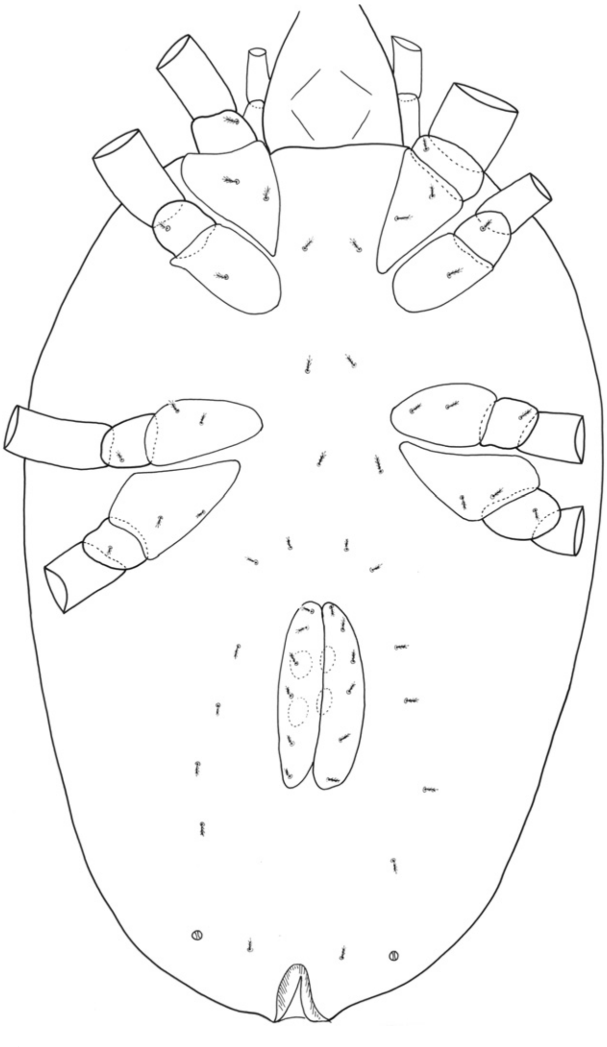

Fig. 3. *Dendrodus acarus* female, ventral idiosoma.

ventral surface of subcapitulum with two prominent grooves arranged in a diamond-shaped pattern. Chelicera (Fig. 5) bluntly rounded distally, proximal half slightly more robust; fixed digit bifurcate, edentate; movable digit small, prominently hooked distally, edentate; without cheliceral setae. Palp (Fig. 6) four-segmented (displaying a fused femurogenu), distal margin of palptarsus tapering; palptarsus with five dendriform-spinose setae (**d**, **l′**, **l′**, **ba** and **p′**), with one dorsoproximal rhagidial organ with a single recumbent solenidion and with two strong terminal erect solenidia near distal margin; tibia and femurogenu with three (**d**, **l′** and **l′**) and two ($\mathbf{d}_1$ and $\mathbf{d}_2$) large dendriform-spinose setae, respectively.

Legs. Leg I–IV shorter than body, all leg segments appear somewhat enlarged, but femur IV not obviously enlarged in relation to other segments; chaetotaxy of legs I–IV, with rhagidial solenidia (γ) and erect solenidia (ϕ) in brackets, as follows: tarsi 16(2γ)-11(2γ)-10-11; tibiae 6(1γ+1ϕ)-5(1γ+1ϕ)-5-4; genua 5(1 ϕ)-4(1 ϕ)-4(1 ϕ)-2(1 ϕ); femora 7-7-4-3; trochanters 1-1-1-1; coxae 2-1-2-2 (see discussion). Rhagidial organ of tarsus I (Fig. 7) with 2 L-type rhagidial solenidia in tandem, each in a separate pit, situated on dorsodistal third of the segment; rhagidial organ of tarsus II (Fig. 8) with two L-type rhagidial solenidia, each in a separate pit, situated on dorsodistal third of the segment, both rhagidial organs I and II without famuli; tibiae I and II each with one rhagidial organ containing a single L-type rhagidial solenidion and one erect solenidion

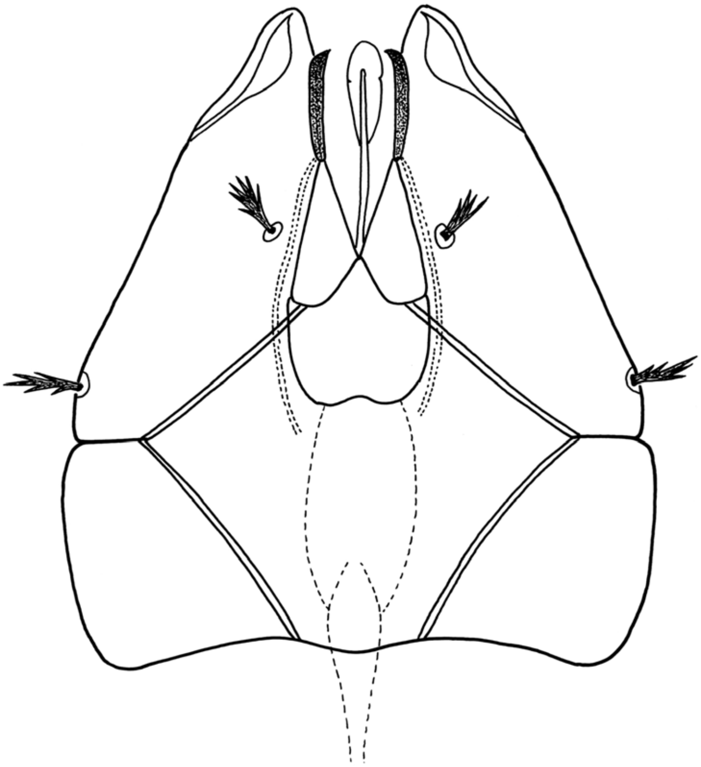

Fig. 4. *Dendrodus acarus* female, subcapitulum.

posterior to the rhagidial organ, both erect solenidia and rhagidial organs situated on dorsodistal third of the segment; genua I–IV each with one erect solenidion on dorsodistal third of the segment.

Etymology. Acar (Gr) = small; refers to the predominantly small setae and general small sized body.

Material examined. SOUTH AFRICA: Northwest Province: Holotype ♀, soil and leaf-litter, Potchefstroom, 26.41S 27.05E, 10.iii.1975, P.D. Theron; two paratype females, same data as holotype. Type material in the National Collection of Arachnida, ARC-Plant Protection Research Institute, South Africa (accession no. Acy:08/79).

DISCUSSION

Various authors, in taxonomic descriptions of a number of different species of eupodoid mites, indicate one or more coxal setae as being inserted 'not within the coxal boundaries' or 'not within the coxal limitations' or 'setae of the intercoxal region', etc. In a study by Baker (1990) it is mentioned that, with the aid of scanning electron microscopy, it

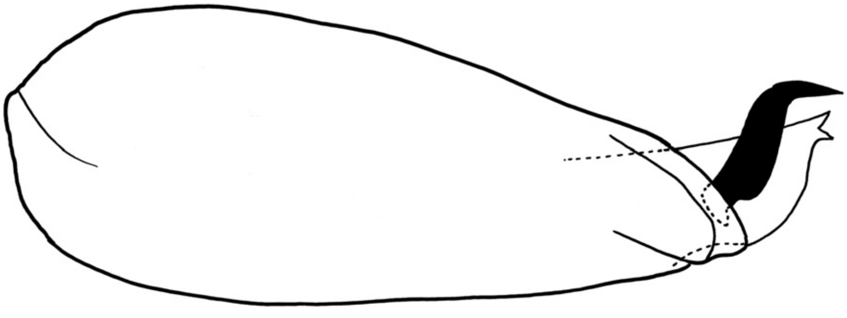

Fig. 5. *Dendrodus acarus* female, chelicera.

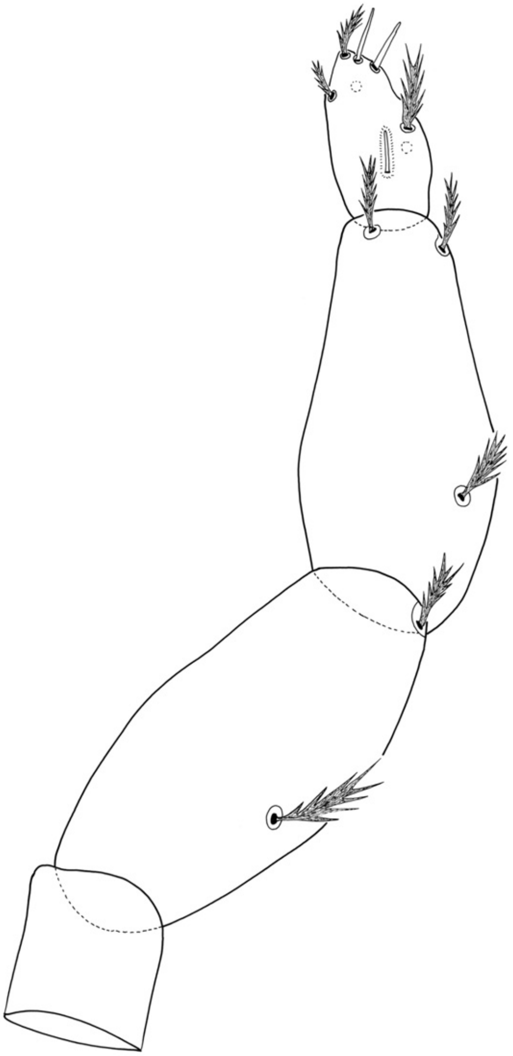

Fig. 6. *Dendrodus acarus* female, palp.

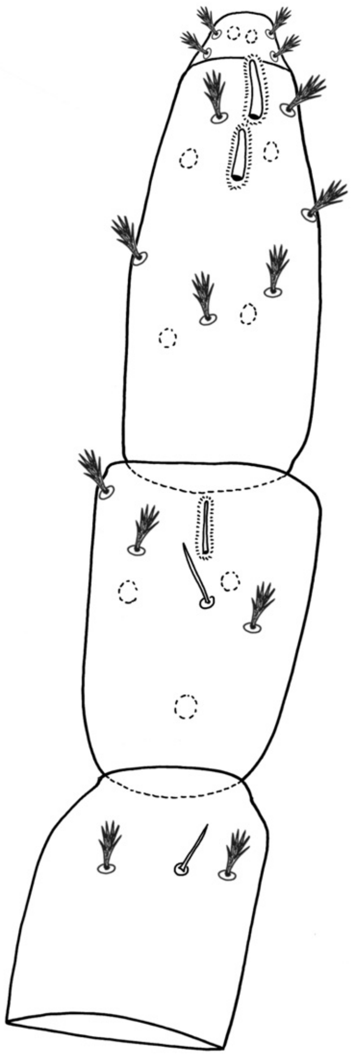

Fig. 7. *Dendrodus acarus* female, tibia, tarsus and genu I.

seems as if these setae are located on 'typical coxal integument'. This was, however, found very difficult to verify using high resolution phase contrast and/or interference contrast microscopy. In many cases the outer boundaries of the coxae are in fact found to be well-defined, and still one or more coxal setae are situated outside the coxal margins. Such setae are usually associated with specific coxal groupings, either being a combination of coxae I, III and IV (each with one seta 'not within the coxal boundaries'), coxae II, III and IV (each with one seta 'not within the coxal boundaries'), coxae III and IV or only coxa IV (with one seta 'not within the coxal boundaries'). Even though these setae are defined to be 'not within the coxal limitations', they are always included as part of the setal formula of the coxae (the latter being a useful taxonomic feature). The most typical coxal formulae for members of the Eupodoidea are indicated as 3-1-3/4-2/3 (Baker 1990) with interspecific variations found for all four coxae (Qin 1996).

In a cladistic study of the Eupodoidea, it is suggested that coxal setae should *not* be used as a single feature expressed as a formula. The number of setae per individual coxal region, with interspecific variations, should rather be considered as separate independent features (Qin 1996). These setae, and more specifically the interspecific variations, however, may include setae of the so-called 'intercoxal region'.

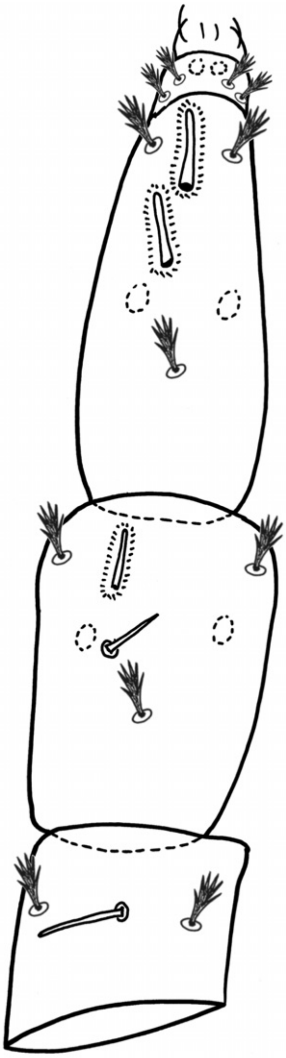

Fig. 8. *Dendrodus acarus* female, tibia, tarsus and genu II.

The question which may be asked is what are 'not within the coxal boundaries' or 'not within the coxal limitations' or setae of the intercoxal region'? The author, therefore, suggests that these setae be considered as 'ventral setae' and treated as such, as is the case with other prostigmatic mites. This will ease and standardize the use of 'coxal formulae' (or number of setae per individual coxal region) as well as 'number of ventral setae' as taxonomic features. It will further allow for the inclusive use of these features for species with multiple ventral and/or coxal setae, such as species of *Penthaleus, Halotydeus* and *Eriorhynchus.* In the above description of *D. acarus,* the coxal formula is, therefore, indicated as 2-1-2-2 and not as 3-1-3-3, while three pairs of 'ventral setae' are distinguished from the normal coxal setae.

One of the more distinctive features of *D. acarus* is the presence of dendriform-spinose setae on both the idiosoma and appendages. Similar setae are also found in some species of Penthaleidae and Pentapalpidae. In *Halotydeus destructor* such setae are restricted to the naso (**iv**), some setae of the palp and the subcapitular setae (**sbc**$_1$ and **sbc**$_2$). *Penthaleus major* displays these setal types only on the palp and some setae of the legs. In members of Pentapalpidae, most of the idiosomal setae (except **T**), the majority of palp setae, cheliceral setae and some setae of the legs are dendriform-spinose. Other than representatives of the Eupodoidea, dendriform-like setae are also found amongst members of some other prostigmatic mites, such as some members of Alycidae (species of *Bimichaelia*) and Nanorchestidae (species of *Speleorchetes* and *Nanorchestes*).

Of the abovementioned eupodoid examples, *D. acarus* is more closely related to species of Pentapalpidae than those of the Penthaleidae. However, members of Pentapalpidae can clearly be distinguished from *D. acarus* by the character combination of a five-segmented palp, **T** being a prominent clavate seta, lacking erect solenidia on genu I–IV, a coxal chaetome of 2-2-4-4, only two pairs of **eg**-setae, each leg tarsus with an apotele with a claw-like empodium lacking lateral empodial claws and the presence of the full complement of cheliceral (**cha** and **chb**) and adoral setae (**or**$_1$ and **or**$_2$). The absence of cheliceral setae in Dendrochaetidae is shared only with species of *Penthalodes, Halotydeus destructor* and possibly also some other species of *Halotydeus.*

A dorsal opisthosoma with fewer than eight pairs of setae is a rare condition in members of Eupodoidea. This phenomenon is shared with *D. acarus* by *H. destructor* (sometimes with seven pairs and one unpaired seta), some species of *Poecilophysis* (Rhagidiidae) and *Protopenthalodes coniunctus* (a member of the Penthalodidae? *cf.* Qin (1996, 1997)). If only seven pairs of dorsal opisthosomal setae are present (hypotrichy), then usually **f**$_2$ or one seta of the **h**-series is lacking (Baker 1990). A more extreme case, however, is displayed in representatives of the genus *Protopenthalodes* where both setae **d**$_1$ and **f**$_2$ are lacking (Jesionowska 1989).

Dendrodus acarus is the only eupodoid species bearing only five setae on the palptarsus. The palptarsus commonly supports nine (in some species of Eupodidae, Penthaleidae and Penthalodidae) or 10 (most species of Rhagidiidae) setae. Some species of *Eupodes* have six or seven setae on the palptarsus (Olivier & Theron 1997b, 1998) and more extreme compliments of as many as 14 setae have also been described (Baker 1990). Frequently the tarsus may also be associated with a rhagidial organ and/or an erect solenidion. However, *D. acarus* seems to be the only species with two erect solenidia, both inserted close to the distoterminal margin of the palptarsus – this as opposed to the two erect solenidia found in *P. major*, one situated distally and one proximally.

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